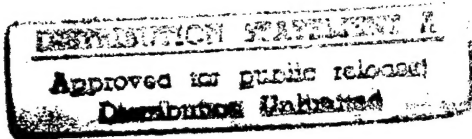


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INTERNAL RADIATION HAZARDS IN INDUSTRY FROM THE
USE OF POLONIUM IN STATIC ELIMINATOR DEVICES

by

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ABSTRACT

A discussion of the internal radiation hazards arising from the use of Polonium in Static Eliminator devices. Special reference is made to the hazards in industry and to the hazards in the handling of these devices by personnel with little or no knowledge of handling and manipulation of radioactive materials. Reference is made to a specific survey of a plant planning to use such devices.

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INTRODUCTION

Radioactive materials have been used effectively in static elimination devices. Although such equipment is efficient, inexpensive and easily produced, the internal radiation hazards involved with the commercial distribution and industrial application of such apparatuses have neither been sufficiently described nor completely investigated. This lack of information and the results of a careful survey of a large printing company, which was about to use one of these devices, has prompted this publication. The physical and radioactive properties of polonium will be discussed and the potential inhalation and ingestion hazards will be given proper emphasis.

THE RATIONALE FOR THE USE OF POLONIUM IN STATIC ELIMINATORS

Elimination of static electricity generated by leather belts moving over cast iron or steel pulleys, paper passing over metal rolls, and film over metal or plastic rolls have been a problem in industry for many years. Many ingenious methods have been devised to eliminate the charge developed. The most widely used method has been to hang strips of thin foil, usually made of aluminum or tin, from the frame of the machine so that they barely touch the surface of the leather belt or paper strip. These foils, acting as conductors, carry the static charge generated on the paper to the frame of the machine which is grounded, thus eliminating the hazard of sparking in the presence of volatile solvents or explosive gases. Static is also a nuisance to workmen even when they know that static electricity is being generated.

Invariably, they are startled when they come in contact with charged material.

The use of foil, however, does have some disadvantages. First, it may not maintain proper contact with the dielectric (e.g., paper or leather belting) and thus the charge is not always grounded. Secondly, dust and other materials frequently collect on the foil and may act as insulating layers, which prevent the foil from having good contact with the dielectric material. Third, since the method appears so simple, workmen tend to become careless, fail to keep the foil clean and the equipment in serviceable condition. Thus the original static problem may remain. Because of these difficulties, other methods have been investigated recently to improve the control of static electricity. Lately, radioactive materials have been used to produce a layer of ionized air between the dielectric material, and some metal portion of the machine which can be grounded easily. Since the usefulness of this type of device depends on the degree of ionization produced in the air, the most effective ionizing agent should be used.

If one measures the radiation from natural radioactive substances such as radium or uranium or those emanating from artificially-produced isotopes, one finds that there are three different types. First, gamma radiation which is an electro-magnetic type and resembles X-rays. Second, beta radiation which is a flow of negatively charged electrons. Third, alpha radiation which is a flow of alpha particles or helium nuclei. Any one or a combination of these types of radiation will produce ionization in the air. However, the most efficient ionizer for this purpose is the alpha particle. Therefore, one would logically

choose an alpha emitter for use in static eliminators.

Both radium and polonium are active alpha emitters and have an energy of approximately 5 million electron volts. Radium has slightly less energy than this value and polonium slightly more. In principle and theory, the use of these substances in static eliminators is excellent. It would seem from these facts that the major problems in static elimination have been solved. However, serious difficulties remain regarding important industrial hazards associated with the employment of these radioactive substances commercially. The fact that even the most energetic alpha particles are barely able to penetrate the keratinized layers of the skin, makes it difficult to comprehend why exposure to alpha radiation can cause internal injury. Nevertheless if alpha particles enter the blood stream either by way of the intestinal tract or through the lungs during inhalation, they may produce some of the most serious types of radiation damage. Internal radiation hazards from polonium must be considered carefully by all persons, plants, or manufacturers before and continuously during the use and production of this type of equipment.

PHYSICAL PROPERTIES OF POLONIUM AND RADIUM

Radium has an atomic number of 88 and an atomic weight of 226. It has a half life of 1590 years. The energy of the alpha particles emitted is 4.79 million electron volts. A weak gamma photon is produced. (.19 million electron volts.). Polonium or radium F has an atomic number of 84, an atomic weight of 210, and a half life of 140 days. Its alpha radiation has an energy of 5.30 million electron volts. A gamma photon of .8 million electron volts is also emitted.

Since both radium and polonium emanate strong alpha rays, they are effective static eliminators. However, polonium is preferable, because on the basis of weight, the strength of the alpha emission is inversely proportional to the half life. Therefore, minute quantities of polonium emanate relatively large amounts of radiation. Also polonium decays into stable lead with an atomic weight of 206, whereas radium decays through a long chain of reactions listed in Figure 1. In these disintegrations, alpha particles are emitted along with many gamma and beta rays which are not so desirable for this use since only energetic alpha rays are needed. It was noted previously that polonium produces gamma rays of only .8 million electron volts. This is in the proportion of one gamma photon for every 1 million alpha particles emitted. Therefore, the gamma radiation is negligible for all practical purposes. Therefore, polonium is an ideal anti-static material because it emits energetic alpha rays; has high specific activity and its decay product is the stable element lead.

THE MECHANISMS OF RADIATION INJURY FROM POLONIUM STATIC ELIMINATORS

With non-penetrating radiations such as the alpha rays emanating from polonium there are two main systems through which such material may enter the human body and cause radiation damage. First, and most important, is absorption from the lungs. When polonium is electro-plated on metal strips for use in static eliminator devices, its strong alpha activity produces a constant bombardment, resulting in a continuous release of tiny particles of the gold plate over the polonium film into the surrounding atmosphere. These minute metal particles usually have small particle size that may cause serious inhalation hazards since

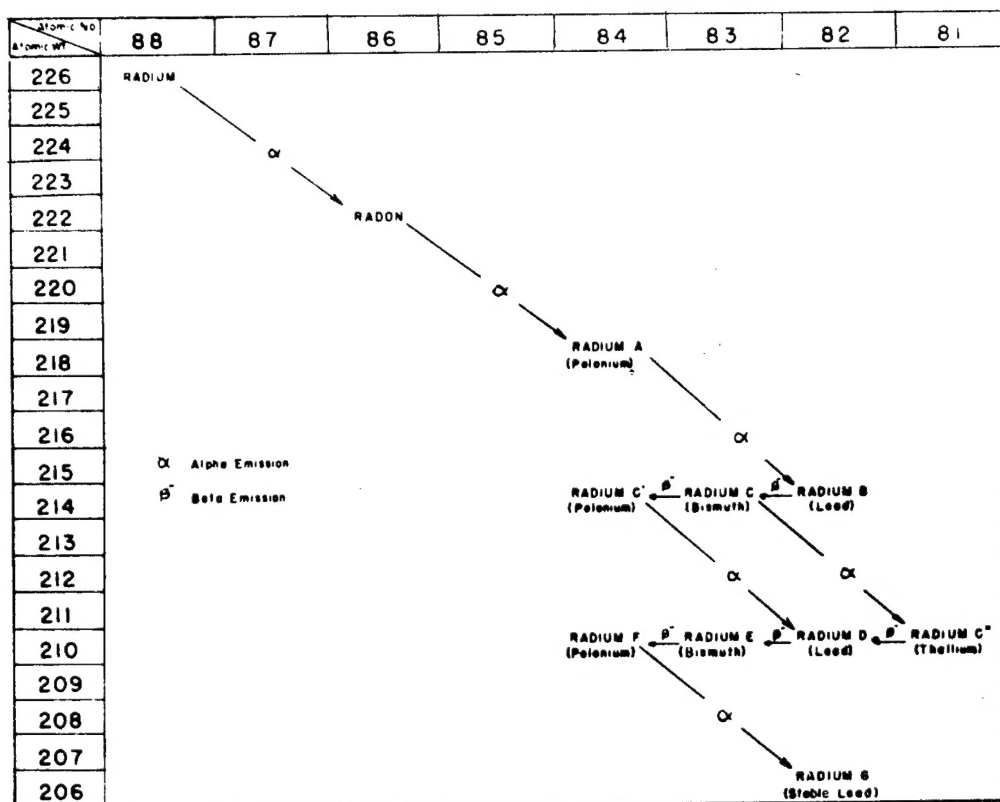


FIGURE 1

ORIGINAL INACTIVE END \



FIGURE 2

they remain suspended in the air for long periods and may be air-borne to the terminal pulmonary passage. When such radioactive particles enter the lungs, they have direct contact with the mucous membranes. Their alpha emission causes intense ionization in these tissues which may destroy cells locally or produce chemical changes in these cells. Later it may cause similar damage in other areas after entering the blood stream either directly through the capillary walls, or indirectly via the lymphatic system. Polonium is excreted in the urine and is a renal toxin. The metabolism of polonium is not completely understood. To date there are no exact data regarding the effects of polonium on the blood forming cells in the bone marrow.

POLONIUM TOLERANCE VALUES

Studies by K. Z. Morgan¹ indicate that approximately five per cent of polonium entering the body through the bowel is localized in the kidneys. The estimated tolerance value for alpha activity is .010 microcuries. Using this figure, the total whole body tolerance would be approximately .20 microcuries, or calculated by weight, approximately 4.5×10^{-11} grams of polonium. The concentration of alpha particles in the air which man may tolerate is estimated to be approximately 10 micro-microcuries per liter of air. For polonium this would be equivalent to 2.2×10^{-15} grams per liter of air.

RADIOLOGIC SURVEY OF A PRINTING ESTABLISHMENT ABOUT TO USE A POLONIUM STATIC ELIMINATOR DEVICE

A large printing company in this area had recently received, by railway express, two packages containing several metal bars. No information was enclosed with the material and no warning notices were placed

on the packages. No labeling was done regarding the identity of the contents. It was known by the company that these bars were to be used on the printing presses as electro-static eliminators. The company officials contacted the California State Department of Health and were made aware of the possible radiation hazards. Therefore, consultations were made with the members of the Radiological Safety Unit at the University of California at Los Angeles Atomic Energy Project in conjunction with members of the California State Department of Public Health. A complete radiological survey of the area was conducted. The metal bars were measured for alpha and beta activity with a Victoreon 356 Alpha Survey Meter over the active and inactive portions of the bars. It was immediately apparent that the supposedly inactive surfaces were grossly contaminated by an alpha emitting substance. One of the members of the State Health Department handled two of the bars, touching only their inactive surfaces. His hands were surveyed with the alpha meter and the alpha activity registered represented an equivalent of twenty-five thousand counts per minute. Calculations, using this value, showed that approximately .02 microcuries of radioactive polonium had been transferred to his hands during this short exposure. Three vigorous washings with Borax soap and water reduced the activity to $1/3$ of its initial value. Continued scrubbing with a hand brush and soap reduced the amount of contamination further but did not completely remove it after 15 separate washings.

The office where the metal bars had been stored for a few days without any unusual amount of handling prior to the survey was shown to be contaminated in many places. The arms of the desk chair, the telephone earpiece, and the inside door knob showed definite alpha activity.

In another specific case some small foils were brought to the authors by an individual that had been using them in his research problem on a study of anti-static devices. This individual had taken the basic information of the literature distributed with the material which proclaimed these foils as non hazardous. Accordingly, he used no handling precautions. The foils were brought in wrapped in tissue and placed in letter envelopes. This person's hands, the outsides of the envelopes, the coat pocket he carried them in, his trouser pockets and his personal effects such as keys, wallet, comb, etc. were highly contaminated. This person and one other associated with him, and who had also handled the active foils, both showed alpha activity in 24-hour urine specimens. The urines were collected in such a manner that no outside alpha contamination was possible. The results show that transfer from hands to mouth is quite possible and occurs with surprising ease. Inside of each of the envelopes the tiny gold flakes could be seen. One of these flakes was removed, and one attempt to check its activity indicated that it was so high that it was off scale on the insensitive range of a Victoreen 356 Alpha Survey Meter. The contamination potential of one of these foils was checked by placing it on a piece of filter paper with supposedly non-active side in contact with the paper. A radioautograph (see Figure #2) was made of the filter paper after the foil was carefully removed. The radioautograph indicated that the so-called protective layer of gold had been almost completely removed along the edges of the foil by previous handling. Also, at one end of the small foil strip where there was originally an inactive area for handling the radioautograph indicated that the highest contamination was present.

OTHER DANGERS FROM POLONIUM USED IN STATIC ELIMINATOR DEVICES

Apparently in the production of these anti-static devices, polonium is obtained from radiolead or radium D. The strips and foils examined showed an appreciable amount of beta radiation which suggests that the polonium may have been contaminated with radium D and E. The half life of radium D is 22 years and it decays with the emission of .025 mev beta and a .047 mev gamma radiation to radium E. Radium E or radiobismuth has a half life of five days and decays with the emission of 1.17 mev beta to polonium. These more penetrating beta radiations emanating from the radiolead and radiobismuth contaminants in the polonium do not appreciably increase the external hazard from such devices but the presence of long life radiolead does increase the hazard from internal radiation. When radiolead is absorbed in the body, some is deposited and remains in the bones. Thus an exposed individual might store in his bones a producer of polonium which could cause serious radiation damage and associated depression of the blood forming cells.

Radiolead behaves like stable lead in the bones of the body. An intercurrent infection or any disturbance in metabolism which produces an acidosis or a diuresis results in mobilization of the lead from the bones into the blood stream and from there to the kidneys and other vital organs of the body. Thus radiolead is not only a serious continuous damaging agent to the bone marrow but intermittently it may cause injury to other vital tissues because of this periodic withdrawal from the bones into the general circulation followed by redeposition in the bones.

DISCUSSION

The results of these preliminary investigations have shown that

the use of polonium in static eliminator devices may produce serious internal radiation injuries. Apparently individuals who are studying the use of these devices and other persons who are involved in research with these radioactive materials have not been sufficiently instructed regarding the possible dangers to which they are subjecting themselves. In addition, it is also apparent that companies producing this equipment for commercial distribution have not been aware of all of the potential dangers. Plating a gold film over the radioactive polonium does not prevent the escape of radioactive material, because of the energetic alpha radiation emitted by polonium. From our observations it is imperative that proper consideration be given to the potential internal radiation hazards in the industrial use of such static eliminating devices, particularly in respect to inhalation and ingestion of these dangerous radioactive substances.

SUMMARY

The use of radioactive materials as static eliminators has been described. Although polonium is an energetic alpha particle emitter and therefore an excellent static eliminator, it has many serious disadvantages. Such devices produce industrial inhalation hazards by contamination of the air with fine particles containing radioactive polonium. Also the ingestion of minute quantities of polonium may cause serious injury. The hazard here is primarily by contamination of the hands. Impure polonium containing radiolead is even more injurious. Therefore, it is recommended that all plants, companies and individuals engaged in the production, investigation and use of such radioactive substances and devices be made cognizant of the dangers from internal

radiation injury. Such plants or persons should be equipped with suitable monitoring instruments and employ properly trained personnel in order to prevent contamination of the area with radioactive agents.

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